PRAGMATIC REASONING SCHEMAS AND THE SELECTION TASK

By

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The present study examined the pragmatic reasoning schema theory of deductive reasoning; specifically its explanation of performance on the selection task. According to this theory, people often reason using pragmatic reasoning schemas, abstract knowledge structures induced from everyday life experiences. Experiment 1 replicated a result crucial to the theory, the finding of facilitation on an abstract form of the selection task. However, Experiments 2, 3, and 4 established that this facilitation was dependent upon two contextual factors: (1) the presence of explicit negatives on the NOT P and NOT Q cards and (2) the inclusion of a checking context in the problem statement.

Overall, the present results do not support the pragmatic reasoning schema theory. They are, however, interpretable in terms of the social contract theory of reasoning or the two-stage (heuristic/analytic) processing

theory. According to the social contract theory explanation, the schema problems are implicit social exchanges with cost-benefit structures. The elimination of the explicit negatives and the removal of the checking context would alter the perception of the cost-benefit structure or make the cost-benefit structure too implicit. According to the heuristic/analytic processing theory explanation, these two changes would affect the heuristic stage of processing in which the information relevant to problem solution is selected. Both changes would lessen the relevance of the NOT Q card.

The present experiments do not allow a crucial test of these two explanations, but the present findings clearly eliminate the pragmatic reasoning schema theory as a viable account of performance on the selection task.

CHAPTER 1
INTRODUCTION

> The selection task has been attacked as subversive because it usually defies the wits of even highly intelligent individuals, and sometimes elicits patterns of behaviour which are distinctly irrational. Hence it is argued we ought to stop using it (Wason, 1983, p. 44).

The Wason selection task (Wason, 1966) has generated considerable interest among psychologists for the past twenty years. Although the problem appears relatively simple, typically less than 10 percent of the subjects solve it correctly (Evans, 1982). As Wason (1983) points out, the selection task has been called "really very complicated" (Finocchiaro, 1980), a "laboratory game" (Wetherick, 1970), a "cognitive illusion" (Cohen, 1981), and quite simply "irritating" (Vuyk, 1981). Performance on the task has figured prominently in arguments concerning human rationality (e.g., Cohen, 1981) and Piaget's theory of formal operations (e.g., Wason, 1977). Without question, it is one of the major tasks that has been used to study human deductive reasoning (Evans, 1982).

In the original (standard) abstract form of the task, subjects are presented with a conditional (If P then Q) rule and an array of four cards representing P, NOT P, Q, and NOT Q. For example, the rule might be "If there is an A on one

side of the card, then there is a 4 on the other side," and the cards A, B, 4 and 7. In addition, subjects are told that each card has a letter on one side and a number on the other side. Their task is to select only those cards that need to be turned over to determine whether the rule is true or false.

Only the P and NOT Q cards (A and 7 in the example) should be selected. This is because only cases of P and NOT Q can falsify the rule. NOT Q may be on the other side of the P card, and P may be on the other side of the NOT Q card. In the example, a number other than 4 on the other side of the A or an A on the other side of the 7 would falsify the rule. Most subjects, however, turn over only the P card (A in the example) or both the P and Q cards (A and 4 in the example). The Q and NOT P cards should not be selected because the rule is true regardless of what is on the other side of these cards.

During the past twenty years, various aspects of the standard abstract task have been varied in the attempt to understand the poor performance on the task and to improve it. The present study examined the most recent general theory of performance on the various forms of the selection task, Cheng and Holyoak's pragmatic reasoning schema theory (Cheng & Holyoak, 1985; Cheng, Holyoak, Nisbett, & Oliver, 1986). Before detailing this theory, a selective review of the relevant literature will be presented. First, matching bias, the major explanation for performance on the standard

abstract form of the task, will be discussed. Next, issues related to manipulations of problem content will be reviewed. The third section will deal with one of the contextual variables that affect performance on the task, the type of task instructions employed. Finally, Cheng and Holyoak's research and theory will be discussed and related to the present study.

Matching Bias

Evans (1972) proposed that the poor performance on the standard form of the selection task might be due to subjects choosing (or matching) those values that were mentioned in the rule, irrespective of the presence of negatives. It is as if the subject thinks the task is about the named cards only. For example, if subjects used matching for the rule, "If there is an A on one side of a card, then there must be a 4 on the other side," then they should most often choose the A and 4 cards. That this is one of the most common answers lends some support to Evans's theory.

In an attempt to provide further evidence for matching bias, Evans and Lynch (1973) systematically manipulated the presence and absence of negative components within the rule. Four types of abstract rules were used: Rules with (1) a positive antecedent (the P component of the conditional) and a positive consequent (the Q component of the conditional), (2) a negative antecedent and a positive consequent, (3) a positive antecedent and a negative consequent, and (4) a

negative antecedent and a negative consequent. Matching was found for all four types of rules. That is, subjects tended to ignore the negatives and select the values mentioned in the rule. For example, if subjects were given a rule such as "If there is an A on one side of a card, then there must not be a 4 on the other side," the values presented in the rule (A and 4) would be selected. In this type of rule (positive antecedent and negative consequent), matching leads to the correct answer!

In summary, Evans and Lynch were able to demonstrate that answers on the standard abstract form of the task are strongly influenced by those values presented in the rule and that subjects do in fact respond in accordance with a matching bias. Subjects appear to be responding in a non-logical manner by selecting the mentioned values because of an attentional bias. Further evidence for and discussion of matching bias are provided in Evans (1982; 1983) and Manktelow and Evans (1979).

Issues Related to Problem Content

The issue of problem content was first discussed in the early 1970s when a few researchers reported good performance for more "thematic" versions of the selection task (e.g., versions dealing with more concrete material such as postage stamps and envelopes, (Johnson-Laird, Legrenzi, & Legrenzi, 1972). This improvement in performance was called the "thematic materials effect." Exactly what was meant by

"thematic" is not clear. The words "thematic," "realistic," and "concrete" have all been used to describe such material (Griggs, 1983). In general, "thematic" material was taken to mean anything except the arbitrarily related symbols and forms (e.g., letters of the alphabet, numbers, geometric patterns, etc.) that were used in the early studies on the standard abstract form of the task.

Wason and Shapiro (1971) first reported a thematic materials effect when they employed rules concerning four journeys the experimenters claimed to have made to two cities (Manchester and Leeds), using two modes of transportation (train and car). For example, one rule went as follows, "Every time I go to Manchester, I travel by car." Results showed that 63% of the subjects made the correct selection on such thematic problems, whereas only 13% provided the correct answer on the standard abstract form of the task.

Johnson-Laird et al. (1972) used a different type of thematic content. They asked subjects to pretend that they were post-office workers sorting letters and to select envelopes that definitely had to be turned over to find out whether or not they violated postal rules such as, "If a letter is sealed, then it has a 50 lire stamp on it." Johnson-Laird et al. observed 81% correct selections for these postal rules and only 15% correct for the standard abstract task.

This thematic materials effect, however, proved to be elusive (Griggs & Cox, 1982). There have been numerous

failures to observe such an effect (e.g., Griggs & Cox, 1982; Manktelow & Evans, 1979; Yachanin & Tweney, 1982).

Griggs and Cox (1982) explained these failures to replicate the thematic materials effect in terms of a memory cuing explanation based on their findings. Although Griggs and Cox did not replicate the findings of Wason and Shapiro (1971) and Johnson-Laird et al. (1972), they did find facilitation for another type of thematic content--a version of the selection task based on the legal drinking age in the state in which their subjects resided (i.e., the rule was "If a person is drinking a beer, then the person is over 19"). Subjects were instructed to imagine that they were police officers responsible for making sure the drinking-age rule was not violated. The four cards represented information about four people sitting at a table. They were labeled "drinking a beer," "drinking a coke," "16 years of age," and "22 years of age." The correct selection rate for this problem was 74% while not one subject got the standard abstract form of the task correct.

Griggs and Cox interpreted their results in terms of a memory-cuing explanation. They argued that performance on the task is facilitated when the presentation environment of the task permits the subject to recall past experience with the content of the problem, the relationship (rule) expressed, and a counterexample to the rule. Their subjects were familiar with this information for the drinking-age law but had no such information, for example, for the postal-type

rules employed by Johnson-Laird et al. (1972). The subjects in the Johnson-Laird et al. study, however, did have such information since there was a postal regulation like this in Great Britain at the time of their study. Further support for the memory cuing explanation was provided by Golding (1981). She found that younger British subjects who were not familiar with the now-defunct postal rule used by Johnson-Laird et al. (1972) tended not to get the postal version of the task correct but that older British subjects who were familiar with the rule tended to make the correct selection.

The memory cuing explanation can explain most cases of facilitation, but has to be expanded to include a reasoning by analogy assumption to explain a few cases of facilitation. For example, some results by D'Andrade (1982) indicate facilitation as a result of memory cuing of general experience. D'Andrade used a thematic version of the selection task in which subjects were told to imagine that they were managers in a Sears store and were responsible for checking sales receipts to determine whether the rule, "If a purchase exceed $30, then the receipt must be approved by the department manager," was followed. One side of each receipt indicated the amount of the purchase, and the other side was either signed or not signed by the manager.

Four sales receipts were presented. They were one for a $15 purchase, one for a $45 purchase, one signed, and one unsigned. D'Andrade found nearly 70% correct selections for this version of the task. It is highly unlikely that

D'Andrade's subjects had specific experience as Sears managers, but it is highly probable that they had experience with analogous materials and relationships; for example, store managers authorizing checks, etc. Thus, what seems to be essential is that the problem cue the subjects to recall specific experience or general experience with the rule.

In summary, the memory cuing/reasoning by analogy hypothesis proposes that the problem content cues familiar information in long-term memory that is used to make the correct selection or, if not directly applicable, is used to derive the answer by a reasoning by analogy process.

Instructional Issues

Researchers who have reported facilitation with thematic and memory cuing materials have since confronted the criticism that the instructions used in almost all of these studies have changed the original nature of the selection task (see Griggs, 1983, for a review). In the original version of the task, subjects were asked to select only those cards necessary to determine whether the rule was true or false. Most of the thematic versions instructed subjects to check the cards to determine whether or not they conform to a given rule rather than to assess the truth status of a rule. Because subjects are also often told to look for violators of the rule, the problem statement may be directing subjects toward falsification strategies.

Yachanin (1986) directly tested the possibility of an instructional effect. Subjects worked on either a familiar or unfamiliar problem with either violation or true-false instructions. The familiar problem was the drinking age problem previously described. The unfamiliar problem was the widgit problem. In this problem, subjects are asked to imagine they are widgit inspectors and presented with the following rule to enforce. "If a widgit has an A on one half of the widgit, then it must have a 3 on the other half." The four cards followed showing "A," "K," "3," and "7." Results indicated that performance was facilitated with familiar material and that the most facilitation was observed when violation instructions were used in conjunction with familiar materials.

Yachanin explained these results in terms of a cognitive trade-off. That is, the facilitative effect of familiar materials was diminished when true-false instructions were used, due to the increased cognitive load of true-false instructions. In other words, there is more mental processing involved with the greater demand of processing two hypotheses, that the rule is true and that the rule is false. He argues that violation instructions on the other hand, free subjects to completely utilize familiar problem content and thus facilitate performance.

Griggs (1984) also examined the effects of type of instructions on the selection task. This study was a replication of Yachanin (1986; reported earlier in Yachanin,

1982), and thus employed the drinking age problem and the widgit problem with both violation and true-false instructions. Griggs's results were similar to those reported by Yachanin (1986). Performance was facilitated on the familiar drinking age problem, with the most facilitation occurring when violation instructions were used with this problem.

In another replication of Yachanin (1986), Chrostowski and Griggs (1985) also reported good performance for the violation version of the drinking age problem, with slightly lower performance on the true-false version of this problem. However, overall performance was facilitated on only the familiar drinking age problem, whereas performance on the widgit problem was poor. They concluded that memory cuing may be a necessary and sufficient condition for facilitation on thematic problems, but that the amount of facilitation is affected by instructions to look for violators.

In one final study relevant to this instructional issue, Valentine (1985) examined the effects of type of instructions on the standard abstract problem. She found that the type of instructions had no effect on the standard abstract problem. This would be expected as performance on the widgit problem, also an abstract problem, was not facilitated with violation instructions. However, she did find that violation instructions increased the subjects' tendency to attempt to verify the rule, while true-false instructions led to increased variability in subjects' answers. Hence, unlike

those results found with thematic, familiar problems, instructions to look for violators of the rule did not affect correct responding on the standard abstract task.

Pollard and Evans (1987) think that the evidence that violation instructions increase the size of the effect with familiar materials is uninterpretable, as the thematic true-false problems employed in the studies previously described are insoluble. They point out that one cannot determine whether a given statement is true or false for four people unless one knows that these individuals are all obeying some rule or law. If one did not have this information, then any card selection would be logically useless. Thus, previous results showing that performance on thematic true-false problems is worse than performance on violation versions of these problems may be due in part to an error in construction of the true-false problems. Therefore, comparisons between performance on true-false versus violation problems should not be made until the true-false problem is rewritten and retested to take this criticism into account.

In summary, researchers concerned with instructional issues found that using violation instructions moderately facilitated performance on thematic problems. However, Pollard and Evans (1987) criticized the true-false versions of these problems as insoluble. Hence, any future work on this contextual issue should heed this criticism.

The discussion will now turn to the most recent theory of selection task performance, Cheng and Holyoak's pragmatic

reasoning schema theory. Because this theory is very different from those previously described and because the present study is a direct test of the theory, Cheng and Holyoak's work will be described in some detail.

Pragmatic Reasoning Schema Theory

Cheng and Holyoak (1985) proposed that people often reason using pragmatic reasoning schemas. They describe pragmatic reasoning schemas as "clusters of rules that are highly generalized and abstracted but nonetheless defined with respect to classes of goals and types of relationships" (p. 294). In other words, subjects reason using abstract knowledge structures induced from everyday life experiences.

One type of schema that they describe is the permissions schema. This includes the set of abstracted rules for situations involving "permission," situations in which some action A may be taken only if some precondition B is satisfied. The four rules, each of which specifies one of the four possible antecedent situations, are: (1) If the action is to be taken, then the precondition must be satisfied; (2) If the action is not to be taken, then the precondition need not be satisfied; (3) If the precondition is satisfied, then the action may be taken; and (4) If the precondition is not satisfied, then the action must not be taken.

According to Cheng and Holyoak, most of the thematic problems that have yielded facilitation fit a permission

schema. For example, the drinking age problem involves a permission schema; some action A may be taken (you may drink alcohol) only if some precondition P is met (you are of legal drinking age). Thus, Cheng and Holyoak argue that we have abstracted rules for permission situations and that when confronted with a permission situation, we invoke these rules.

Since the rules of some schemas lead to the same conclusions as do the rules of standard logic, the answers given on such reasoning problems will appear as if logically derived (e.g., as in the drinking age problem). In such situations subjects may have chosen their answers based on a pragmatic reasoning schema, rather than based on the rules of standard logic. Cheng and Holyoak explain performance on several thematic versions of the selection task in this way. For these problems, the response that follows from the conditional rule is the same as that which follows from the rules that comprise the permission schema described above.

The standard abstract form of the selection task does not invoke a pragmatic schema. Thus, subjects do not perform very well on it. To provide clearcut evidence for their theory, especially their assumption that abstract schemas are not bound to any domain-specific content, Cheng and Holyoak devised an abstract permission schema version of the selection task and experimentally studied it. Because this is the experiment crucial to the present study, it will be described in detail.

Cheng and Holyoak (1985, Experiment 2) attempted to invoke a permission schema using abstract materials. Their permission problem read as follows: "Suppose you are an authority checking whether people are obeying certain regulations. The regulations all have the general form, 'If one is to take action 'A,' then one must first satisfy precondition 'P.'' In other words, in order to be permitted to do 'A,' one must first have fulfilled prerequisite 'P.' The cards below contain information on four people: One side of the card indicates whether or not a person has taken action 'A,' the other indicates whether or not the same individual has fulfilled precondition 'P.' In order to check that a certain regulation is being followed, which of the cards below would you turn over? Turn over only those that you need to check to be sure." The four cards followed showing, "Has taken action A," "Has not taken action A," Has fulfilled precondition P," "Has not fulfilled precondition P." They compared performance on this problem to performance on the standard abstract problem described above.

Cheng and Holyoak found that subjects did significantly better on the permission problem (61% correct) than on the standard abstract problem (19% correct). It was concluded that a permission schema had been invoked and that this accounted for the observed effect. The observed facilitation on the abstract permission problem should be considered a noteworthy finding. Performance on an abstract version of the selection task has never been as good as that on the

abstract permission problem. Thus, this facilitation is a crucial piece of evidence for the pragmatic reasoning schema theory.

Cheng, Holyoak, Nisbett and Oliver (1986, Experiment 3) later examined the effects of specific training in pragmatic reasoning schemas. The schema examined in this case was the "obligation" schema, which has the following form, "If situation I arises, then action C must be done." However, only thematic versions of the obligation schema were examined. The thematic obligation schema problems were solved more often than the standard abstract problem (64% correct versus 27% correct). In addition to the schema effect, training on obligation schemas improved performance on thematic obligation problems (64% correct -- no training, 92% correct -- training). Thus, Cheng and Holyoak have extended their theory to thematic versions of obligation schema problems, but they have only tested one abstract schema problem (i.e., the abstract permission schema).

Cheng and Holyoak's most important finding with respect to the present study is the facilitation observed for the abstract permission schema problem. This facilitation is unusual because the problem is written in abstract form. That is, it depicts a relationship between letters of the alphabet. Although this problem revolves around a schema, it certainly does not deal with familiar information cued in from memory. Furthermore, it is doubtful that one could reason by analogy with such material. Thus, Cheng and

Holyoak's results cannot be explained by the memory cuing/reasoning by analogy theory.

However, the structure of the schema problems used by Cheng and Holyoak is closer in form to violation versions of thematic problems than to the original true-false version of the task. As noted previously, the facilitative effect of violation instructions has only been observed for thematic content that cues familiar information in memory, but facilitation has never been observed on an abstract form of the task. Thus, it is possible that the violation nature of the abstract permission schema problem contributes to the facilitation observed for it.

General Overview of Study

Experiment 1 attempted to replicate Cheng and Holyoak's facilitation for the abstract permission schema problem. An abstract obligation schema problem was also examined to determine whether the facilitation effect occurs with abstract schema problems other than the permission problem. Because only thematic obligation problems have been examined, this seemed like a necessary and logical step. In addition, type of instructions (violation vs. true-false) was varied for all problems.

Experiments 2, 3, and 4 examined factors other than pragmatic reasoning schemas as possible sources of the facilitation observed by Cheng and Holyoak. These factors, the use of explicit negatives on the NOT P and NOT Q cards

and the employment of a "checking" context in the problem statement, will be detailed in the introductions to Experiments 2 and 4.

CHAPTER 2
EXPERIMENT 1

One condition of Experiment 1 comprised a replication of Cheng and Holyoak's Experiment 2, (1985). In this condition, subjects were given Cheng and Holyoak's abstract permission problem and a violation version of the standard abstract problem (what Cheng and Holyoak called the "arbitrary" problem). Another condition extended their study. In this condition, subjects were given an abstract obligation schema problem and a violation version of the standard abstract problem. The abstract obligation schema problem has never been studied. Based on Cheng and Holyoak's results for the abstract permission schema problem, facilitation was expected for both types of abstract schema problems.

Both the abstract permission schema problem used by Cheng and Holyoak and the abstract obligation schema problem used in the present study are violation forms of the selection task. As discussed earlier, a violation version changes the nature of the task. The subject is asked to reason from a rule rather than about a rule. This may reduce the cognitive load for the task and lead to facilitation. Thus, the facilitation observed on the abstract permission schema problem may be due partly to the violation nature of the problem instead of just the invocation of the permission schema.

In order to determine if the violation context of the problem is in fact responsible for some of the observed facilitation, the present experiment employed both violation and true-false versions of the abstract permission, abstract obligation, and standard abstract problems. Thus, there were two more conditions just like the two already described except true-false versions of the problems were used.

If the violation context provides facilitation, then performance on the true-false versions should be poorer than performance on the violation versions. The true-false problems took into account criticisms of previous thematic true-false versions of the selection task (Pollard & Evans, 1987). Thus, they were not insoluble as previous versions may have been.

Method

Subjects

One-hundred and sixty University of Florida undergraduates enrolled in General Psychology courses served as subjects. They participated as part of the research requirement for the course. None of the subjects had any previous experience with the selection task.

Design

Each subject received two problems. One problem was an abstract permission or obligation problem, with either violation or true-false instructions. The other problem was the standard abstract problem, with the same type of

instructions. Thus, there were four conditions. Twenty subjects in each condition received the schema problem first, and twenty subjects received it second.

The four cards in each problem were ordered either P, NOT P, Q, NOT Q, or the reverse. Each subject received a different ordering of the cases for each problem. The ordering of the cards was counterbalanced across problems.

Materials

The violation version of the permission problem read as follows:

> Suppose you are an authority checking whether or not people are obeying certain regulations. The regulations all have the general form, "If one is to take action 'A,' then one must first satisfy precondition 'P.'" In other words, in order to be permitted to do "A," one must first have fulfilled prerequisite "P."
>
> The cards below contain information on four people: One side of the card indicates whether or not a person has taken action "A," the other indicates whether or not the same individual has fulfilled precondition "P." In order to check that a certain regulation is being followed, which of the cards below would you turn over? Turn over only those that you need to check to be sure.

The problem was followed by drawings of four cards showing the four cases as follows: "Has taken action A," "Has

not taken action A," "Has fulfilled precondition P," and "Has not fulfilled precondition P."

The true-false version of the permission problem read as follows:

> Suppose you have just started a new job as an authority checking whether or not people are obeying certain regulations. The cards below contain information on four people: One side of the card indicates whether or not a person has taken action "A," the other indicates whether or not the same individual has fulfilled precondition "P." Here is a regulation, "If one is to take action 'A,' then one must first satisfy precondition 'P.'" In other words, in order to be permitted to do "A," one must first have fulfilled prerequisite "P."
>
> You know that these four people are following company regulations. However, since you are still unfamiliar with your job, you must find out whether the above regulation is true or false for these four people. In order to check, which of the cards below would you turn over? Turn over only those cards that you need to check to determine if the regulation is true or false for the four people.

The four cards were the same as in the violation version.

The violation version of the obligation problem read as follows:

> Suppose you are an authority checking whether or not people are obeying certain regulations. The regulations all have the general form, "If situation 'I' arises, then action 'C' must be done." In other words, if situation "I" comes about, then one is obliged to complete action "C."
>
> The cards below contain information on four people: One side of the card indicates whether or not a person is in situation "I," the other indicates whether or not the same individual has completed action "C." In order to check that a certain regulation is being followed, which of the cards below would you turn over? Turn over only those that you need to check to be sure.

The above instructions were followed by drawings of four cards showing the four cases: "Situation I has arisen," "Situation I has not arisen," "Action C completed," "Action C not completed."

The true-false version of the obligation problem read as follows:

> Suppose you have just started a new job as an authority checking whether or not people are obeying certain regulations. The cards below contain information on four people: One side of the card indicates whether or not a person is in situation "I," the other indicates whether or not the same individual has completed action "C." Here

is a regulation, "If situation 'I' arises, then action 'C' must be done." In other words, if situation "I" comes about, then one is obliged to complete action "C."

You know that these four people are following company regulations. However, since you are still unfamiliar with your job you must find out whether the above regulation is true or false for these four people. In order to check, which of the cards below would you turn over? Turn over only those cards that you need to check to determine if the regulation is true or false for the four people.

The cards were the same as in the violation version.

The violation version of the standard abstract problem read as follows:

Below are four cards. Every card has a letter on one side and a number on the other. Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain rule is being followed. The rule is: "If a card has an 'A' on one side, then it must have a '4' on the other side. In order to check that the rule is being followed, which of the cards below would you turn over? Turn over only those cards that you need to check to be sure.

Drawings of the four cards followed, showing the four possible cases: "A," "B (NOT A)" "4," "7 (NOT 4)." The

parenthetical "NOTs" were included on the cards because Cheng and Holyoak (1985) used them. They argued that this allowed the cards in the standard abstract problem to more closely match the syntactic form of the cards in the abstract permission schema problem.

The true-false version of the standard abstract problem read as follows:

> Below are four cards. Every card has a letter on one side and a number on the other. Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain rule is true or false. The rule is: "If a card has an 'A' on one side, then it must have a '4' on the other side." You know that the four cards below are following some rule. However, you are not sure whether the above rule is true or false for these four cards. Turn over only those cards that you need to check to determine whether the rule is true or false for the four cards.

The cards were the same as in the violation version.

Procedure

Subjects were run in large groups, with the largest group being almost 100 subjects. A three-page booklet was used. General task instructions were given on the first page. Subjects were told that they would be working on two reasoning problems and that they were to work on them in the order they were presented in the booklet. The two problems

followed, one on a page. Subjects were instructed not to turn back to a problem once they had completed it.

Results and Discussion

First, the percentage correct results for the schema problem and the standard abstract problem within each condition will be reported. This is the type of analysis used by Cheng and Holyoak (1985). Possible presentation order effects will also be examined in order to test for transfer effects.

Secondly, the frequencies of the various selection combinations will be reported for all three problems (permission, obligation, and standard abstract) within each condition. These data will allow us to see if any of the problems led to selection combinations that are not typically observed.

Finally, some parametric analyses of the data within each condition will be reported. Pollard and Evans (1987) presented a new way of coding selection task data using what they call logic and matching indices. For logic indices, subjects are given +1 if they choose the P or NOT Q cards, and -1 for NOT P or Q selections. For matching indices subjects are given +1 if they choose P or Q, and -1 if they choose NOT P or NOT Q. These indices yield a value on a 5-point scale that can be analyzed using analysis of variance techniques. In general, the logic indices indicate the degree of correct responding; whereas the matching indices

indicate the degree of matching (i.e., selecting the values mentioned in the rule).

Percentage Correct and Transfer Results

The percentage correct for each problem in each of the four conditions is presented in Table 2-1. Performance in the condition replicating the Cheng and Holyoak experiment was comparable to that reported by Cheng and Holyoak (1985). Fifty-three percent of the subjects solved the violation version of the abstract permission problem in the present experiment (Cheng and Holyoak found 55% correct selections). This was significantly better performance than on the violation version of the standard abstract task (23% correct selections), [X^2 (1, N=80) = 7.68, $p < .01$]. Performance on the violation version of the obligation schema problem was also as predicted. The percentage correct for this problem (35%) was significantly greater than on the violation version of the standard abstract task (15%), [X^2 (1, N=80) = 4.27, $p < .05$]. Performance on the violation versions of the two schema problems was not significantly different.

Similar results were observed in the two true-false conditions. In each case, performance was better for the schema problem (both p's $< .05$); and performance on the two schema problems was not significantly different.

Although facilitation was observed for all of the abstract schema problems, no significant transfer (positive

TABLE 2-1

Percentage Correct for each Problem in Experiment 1

Type of Instructions	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
Violation	53%	23%	35%	15%
True-False	38%	3%	28%	10%

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

or negative) was observed between any of these problems and the standard abstract problem.

As shown in Table 2-1, performance on the true-false versions of each problem was worse in every case. However, only one of these differences was significant. This was the difference for the standard abstract task in the permission conditions (23% vs. 3%), [X^2 (1, N=80) = 7.31, $p < .01$].

This may be an anomalous result since no transfer was observed in the violation condition and a difference between violation and true-false forms of the standard abstract task has never been reported. It may be that subjects in the violation condition did not follow the instructions not to go back and forth between problems. By doing so, their performance on the standard abstract test, especially when it was first, was improved. Although this is only speculative, it would account for the unexpected significant difference.

Selection Combinations Results

The frequencies of the various card selection combinations (including single-card selections) are presented in Tables 2-2 and 2-3. The results for the violation conditions are given in Table 2-2, and the results for the true-false conditions in Table 2-3. Overall, the selection combinations for the standard abstract problem were not unusual. Most subjects made the common errors. The most prevalent incorrect selections were either the P card only and the P and Q cards.

TABLE 2-2

Frequency of Selection Combinations for the Violation Problems in Experiment 1

Selection	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
P	9	5	4	10
NOT P	0	0	0	0
Q	2	0	5	1
NOT Q	1	0	2	0
P, Q	2	18	5	16
P, NOT Q[c]	21	9	14	6
NOT P, NOT Q	0	5	3	5
P, Q, NOT Q	0	0	5	0
All of the Cards	0	1	2	1
Other[d]	5	2	0	1

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 2.

TABLE 2-3

Frequency of Selection Combinations
for the True-False Problems in Experiment 1

Selection	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
P	9	9	7	12
NOT P	0	2	1	0
Q	2	1	0	0
NOT Q	3	1	2	0
P, Q	4	23	14	14
P, NOT Q[c]	15	1	11	4
All of the Cards	0	1	1	3
Other[d]	7	2	4	7

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 2.

As facilitation was observed on all schema problems, the most prevalent answer in these conditions was P and NOT Q, the correct one. In addition, the patterns of incorrect selections for these problems were fairly typical.

Analyses of Logic and Matching Indices

Two two-way analyses of variance (ANOVAs) were performed on both the logic indices and the matching indices. For each index, one ANOVA was done on the data for the conditions using the abstract permission schema problems and one was done for the conditions using the abstract obligation schema problems. The two factors in each case were type of problem (abstract schema vs. standard abstract) and type of instructions (violation vs. true-false).

The ANOVAs performed on the logic indices revealed that type of problem (abstract schema versus standard abstract) was significant for the conditions using permission problems [$F(1, 80) = 23.28$, $p < .001$] and for the conditions using obligation problems [$F(1, 80) = 5.84$, $p < .05$]. However, type of instructions (violation versus true-false) was not significant in either analysis. Table 2-4 shows the mean logic indices for these analyses.

Overall, these findings support Cheng and Holyoak's pragmatic reasoning schemas theory. Subjects performed significantly better on the schema problems than on the standard abstract problems. In addition, the pragmatic reasoning schema effect was demonstrated for the abstract

TABLE 2-4

Mean Logic and Matching Indices for each Problem in Experiment 1

Type of Instructions	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
		Logic Indices		
Violation	1.150	0.550	0.850	0.525
True-False	0.875	0.225	0.775	0.525
		Matching Indices		
Violation	0.350	0.750	0.400	0.825
True-False	0.275	1.325	0.775	0.925

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

obligation schema problem, which has not previously been tested.

The mean matching index for each problem are given in Table 2-4. The ANOVA on the matching indices for the conditions using permission schema problems yielded a significant effect of type of problem [$F(1,80) = 22.23$, $p < .001$]. This indicates that subjects tended to match more often on the standard abstract problems than on the permission schema problems. Very little matching was observed on the permission problems as the most common answer here was the correct one. No other significant effects were observed.

The ANOVA on the matching indices for the conditions using obligation problems yielded no significant differences, although the effect of type of problem was marginally significant [$F(1,80) = 3.72$, $p < .10$]. Subjects again tended to use a matching bias more frequently for the standard abstract problems.

CHAPTER 3
EXPERIMENT 2

The use of explicit negatives on the NOT P and NOT Q cards in the abstract schema problems may have reduced the matching bias tendency for these problems and increased the tendency to answer in accordance with logic. The results of Evans (1983) for a conditional truth table task clearly indicate this may be the case.

In the conditional truth table task, the subject is presented with a conditional (If P then Q) statement and then the four possible combinations of antecedent and consequent (both are true, antecedent is true and consequent is false and vice-versa, and both are false). The subject's task is evaluating the truth status of the four cases. As in the selection task, the only falsifying case is when the antecedent (P) is true and the consequent (Q) is false. The instances to be evaluated are presented as conjunctive sentences. For example, the rule might be "If the letter is D, then the number is 4" and the instance to be evaluated, "The letter is D and the number is 7." Because this is an instance of P (D) and NOT Q (7), the correct evaluation of this case would be false.

As in the standard abstract selection task, subjects' performance on the truth-table evaluation task indicates a matching bias. Subjects usually only choose the cases in

which the values match those given in the rule as true, regardless of negatives. However, Evans (1983), by employing explicit negatives in the statement of the various instances (e.g., "The letter is D and number is not 4"), was able to significantly reduce matching bias and significantly increase the logically correct clarification of true antecedent/consequent and true antecedent/false consequent cases.

If the explicit negatives in the abstract schema problems functioned in a similar way, then they, and not the cuing of pragmatic reasoning schemas, would be responsible for the facilitation observed by Cheng and Holyoak (1985) and in the present Experiment 1. This hypothesis was tested in Experiment 2.

In Experiment 2, subjects were tested again on either an abstract permission or obligation schema problem and the standard abstract problem, both with either violation or true-false instructions. Thus, the four conditions employed in this experiment were the same as those in Experiment 1. The only difference was in how the NOT P and NOT Q cards were worded. In Experiment 2, these two cards did not use explicit negatives. Given Evans's (1983) findings, no facilitation on these schema problems was expected.

Method

Subjects

One-hundred and sixty University of Florida undergraduates enrolled in General Psychology courses served as subjects. Subjects participated as part of the research requirement for the course. None of the students had any previous experience with the selection task.

Design and Procedure

The design and procedure were the same as in Experiment 1.

Materials

The problems were the same as those in Experiment 1, except that the NOT P and NOT Q card statements were changed. For the permission problems, the four cards were: "Has taken action A," "Has taken action B," "Has fulfilled precondition P," and "Has fulfilled precondition Q." The four cards for the obligation problems were: "Situation I has arisen," "Situation K has arisen," "Action C completed," and "Action D completed." In the standard abstract problem the parenthetical explicit negatives were removed from the NOT P and NOT Q cards. The cards were: "A," "B," "4," and "7."

Results and Discussion

As in Experiment 1, the percentage correct analyses for all problems will be presented first; and comparisons will be made between problems. In addition, any transfer effects will be noted. The selection combination data will be

presented next. Finally, the analyses of logic and matching indices will be presented.

Percentage Correct and Transfer Results

The percentage of subjects solving each problem is presented in Table 3-1. Performance on all of the problems was poor (average percent correct across problems was 6.5%). There were no significant differences in performance between any of the problems. Thus, the facilitation observed in Experiment 1 for schema problems disappeared in Experiment 2 when the explicit negatives were removed from the cards. Because the number of correct selections was so low in all conditions, it was impossible to observe any transfer.

Selection Combinations Results

The frequency of the various card selection combinations are presented in Tables 3-2 for the violation problem and 3-3 for the true-false problems. Most subjects made common errors on all the problems. The most prevalent selection combinations were again only the P card and the P and Q cards.

Analyses of Logic and Matching Indices

As in Experiment 1, two two-way ANOVAs were performed on both the logic indices and the matching indices. For each index, one ANOVA was performed on the data for the conditions using the abstract permission schema problems and one was run for the conditions using the abstract obligation schema problems. The two factors in each case were type of problem

TABLE 3-1

Percentage Correct for each Problem in Experiment 2

Type of Instructions	Type of Problem			
	Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
Violation	3%	5%	5%	8%
True-False	13%	10%	3%	5%

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

TABLE 3-2

Frequency of Selection Combinations for the Violation Problems in Experiment 2

Selection	Type of Problem			
	Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
P	14	12	11	11
NOT P	2	0	2	1
Q	9	5	2	1
NOT Q	0	0	0	0
P, Q	6	13	11	17
P, NOT Q[c]	1	2	2	3
P, NOT P	0	0	3	0
All of the Cards	1	4	6	4
Other[d]	7	4	3	3

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 2.

TABLE 3-3

Frequency of Selection Combinations
for the True-False Problems in Experiment 2

Selection	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
P	15	16	12	8
NOT P	0	0	0	0
Q	6	2	5	3
NOT Q	0	0	1	0
P, Q	7	12	12	18
P, NOT Q[c]	5	4	1	2
NOT P, NOT Q	0	0	5	0
P, Q, NOT Q	0	0	0	3
All of the Cards	1	1	1	2
Other[d]	6	5	3	4

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 2.

and type of instructions. Table 3-4 shows the mean logic indices and mean matching indices.

There were no significant effects in either ANOVA for the logic indices. This agrees with the analyses on the percentage correct data.

The ANOVA performed on the matching indices for the conditions involving the permission problems revealed no significant effects. However, the ANOVA for the conditions using obligation schema problems found a significant difference between problem type [$F(1,78) = 5.2$, $p < .05$]. There was more matching on the standard abstract problem.

The results of the present experiment indicate that when the explicit negatives were removed from the NOT P and NOT Q cards, the facilitative effect for the abstract schema problems disappeared. Thus, the facilitation cannot be attributed to pragmatic reasoning schemas. In addition, the facilitative effect cannot be due to explicit negatives only; or performance on the standard abstract problems in Experiment 1 would have been better. The remaining experiments will attempt to clarify this facilitation and determine its true nature.

TABLE 3-4

Mean Logic and Matching Indices for each Problem in Experiment 2

Type of Instructions	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
		Logic Indices		
Violation	0.150	0.275	0.300	0.300
True-False	0.500	0.550	0.275	0.350
		Matching Indices		
Violation	0.800	1.125	0.750	1.050
True-False	0.850	0.975	0.825	1.150

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

CHAPTER 4
REPLICATION OF EXPERIMENT 2

Although the results from Experiment 2 supported the predictions made for that study, it was discovered that the wording used in the schema problems may have been ambiguous. For example, the permission problem contained the sentence: "The cards below contain information on four people: One side of the card indicates whether or not a person has taken action 'A,', the other indicates whether or not the same individual has fulfilled precondition 'P.'" This statement might not have been interpreted as involving only one action and one precondition. If not, then subjects may have assumed that individuals could fulfill both preconditions. If this were the case, then performance on the schema problems in Experiment 2 might have been poor because of this confusion instead of the absence of explicit negatives.

To examine this possibility, Experiment 2 was repeated with the working amended; but the wording in the abstract schema problems was amended so that neither problem statement was ambiguous.

Method

Subjects

One-hundred and sixty University of Florida undergraduates enrolled in General Psychology courses served

as subjects. Subjects participated as part of the research requirement for the course. None of the subjects had any previous experience with the selection task.

Design and Procedure

The design and procedure were the same as in the first two experiments.

Materials

The problems were the same as those in Experiment 2, except that minor changes were made in the schema problem statements to clarify what was on each side of a card. In the permission problem the sentence, "One side of the card indicates whether or not a person has taken action 'A,' the other indicates whether or not the same individual has fulfilled precondition 'P'," was changed to "One side of the card indicates what action a person has taken; the other indicates what precondition the same individual has fulfilled." In the obligation problem the sentence "One side of the card indicates whether or not a person is in situation 'I,' the other indicates whether or not the same individual has completed action 'C'," was changed to "One side of the card indicates what situation a person is in; the other indicates what action the same individual has completed."

Results and Discussion

The results will be presented in the same way as in the first two experiments. The percentage correct data will be

reported first, then the selection combination results, and finally the ANOVAs on the logical and matching indices.

Percentage Correct and Transfer Results

The percentage correct data are presented in Table 4-1. Performance was poor again in all conditions (average percent correct across problems was 5.75%). There were no significant differences between problems. Thus, the poor performance observed in Experiment 2 was the result of the absence of the explicit negatives and not an ambiguity in the problem statement.

As in Experiment 2, it was impossible to observe any transfer effects due to the overall poor performance on all of the problems.

Selection Combinations Results

The frequency of the various card selection combinations are presented in Tables 4-2 for violation problems and 4-3 for true-false problems. Most subjects again made the typical errors. The P card only and the P and Q cards were the most frequent selections.

Analyses of Logic and Matching Indices

As in Experiment 2, two two-way ANOVAs were performed on both the logic and matching indices. The mean logic and matching indices are shown in Table 4-4.

None of the factors in any of the analyses were significant. The mean logic indices were uniformly low. In contrast, the matching indices were all relatively high, indicating matching for all of the problems.

TABLE 4-1

Percentage Correct for each Problem
in Replication of Experiment 2

Type of Instructions	Type of Problem			
	Abstract Permission Problem	Standard Abstract Problem	Abstract Obligation Problem	Standard Abstract Problem
Violation	8%	0%	8%	5%
True-False	8%	8%	3%	6%

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

TABLE 4-2

Frequency of Selection Combinations for the Violation Problems in Experiment 2

Selection	Type of Problem			
	Abstract Permission Problem	Standard Abstract Problem	Abstract Obligation Problem	Standard Abstract Problem
P	13	12	14	17
NOT P	0	0	0	0
Q	4	2	2	3
NOT Q	0	0	0	0
P, Q	13	18	14	11
P, NOT Q[c]	3	0	3	2
NOT P, NOT Q	0	3	0	0
All of the Cards	1	2	2	4
Other[d]	6	3	5	3

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 2.

TABLE 4-3

Frequency of Selection Combinations for the True-False Problems in Replication of Experiment 2

Selection	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
P	13	11	15	19
NOT P	0	1	3	2
Q	0	1	3	1
NOT Q	0	1	0	0
P, Q	14	18	9	12
P, NOT Q[c]	3	3	1	2
NOT P, NOT Q	3	0	0	0
P, NOT P	5	0	0	0
All of the Cards	0	2	1	2
Other[d]	2	3	8	2

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

[c]This is the correct selection.

[d]The frequency of each of these selections was ≤ 1.

TABLE 4-4

Mean Logic and Matching Indices for each Problem in Replication of Experiment 2

Type of Instructions	Type of Problem: Abstract Permission Problem	Standard Abstract Problem[a]	Abstract Obligation Problem	Standard Abstract Problem[b]
		Logic Indices		
Violation	0.375	0.300	0.475	0.450
True-False	0.475	0.375	0.175	0.475
		Matching Indices		
Violation	1.025	1.150	1.075	1.000
True-False	0.875	1.175	0.725	1.025

[a]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract permission problems.

[b]The results in this column are for the standard abstract problems (violation and true-false versions) paired with the violation and true-false abstract obligation problems.

Overall, the results for this replication of Experiment 2 are in agreement with the original Experiment 2. Even after the potential ambiguity in problem wording was eliminated, subjects still performed very poorly on both abstract schema and standard abstract problems. Thus, it appears that the explicit negatives on the NOT P and NOT Q cards may be necessary for facilitation to be observed on the abstract schema problems.

CHAPTER 5
EXPERIMENT 3

Experiment 3 was an attempt to promote facilitation on the standard abstract problems by using explicit negatives on the NOT P and NOT Q cards in the same manner they were employed in the schema problems. In Experiment 1 and in Cheng and Holyoak's Experiment 2 (1985), the explicit negatives in the standard abstract problems were enclosed in parentheses following the NOT P and NOT Q instances [i.e., B (NOT A), and 7 (NOT 4)]. The salience of the negatives, and thus their effect, may have been diminished by the presence of the actual NOT P and NOT Q instances (B and 7). Experiment 3 examined this hypothesis. In addition, the results will help to determine whether the facilitation for the schema problems is due only to the explicit negatives or to an interaction of explicit negatives with the problem statements. Facilitation for the standard abstract problem with explicit negatives would suggest only the explicit negatives are responsible for the facilitation. No facilitation would indicate an interactive effect.

Method

Subjects

Forty University of Florida undergraduates enrolled in an undergraduate economics course served as subjects.

Subjects participated as part of the research requirement for this course. None of the subjects had any previous experience with the selection task.

Design

All subjects worked on the same abstract problem. The only difference between conditions was in the card display. In the explicit negatives condition, the NOT P and NOT Q cards used explicit NOTs. In the control condition, implicit negatives were used.

There were twenty subjects in each condition, and each subject worked on only one problem. The four cases to be selected in each problem were ordered either P, NOT P, Q, NOT Q or the reverse.

Materials

The violation version of the arbitrary problem read as follows:

> Below are four cards. Every card has a letter on one side and a number on the other. Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain rule is being followed. The rule is: "If a card has an 'A' on one side, then it must have a '4' on the other side. In order to check that the rule is being followed, which of the cards below would you turn over? Turn over only those cards that you need to check to be sure.

Drawings of the four cards followed, showing "A,", "B," "4," and "7" for the control condition and "A," "NOT A," "4," "NOT 4," for the explicit negatives condition.

Procedure

Subjects were run in one large group. Each subject was given only one problem. General task instructions were given orally.

Results and Discussion

The results will be presented as in the previous experiments.

Percentage Correct Results

The percentage of subjects solving the problems in each of the two conditions was the same, 10%. Thus, using explicit negatives with the standard abstract problem does not enhance performance as it does with the abstract schema problems.

Selection Combinations Results

The frequency of the various card selection combinations are presented in Table 5-1 for both problems. For the standard abstract problem, the selections were typical, mostly P only and P and Q. For the standard abstract problem with explicit negatives, P and Q was a common selection. However, only two subjects selected just the P card. Instead, the remainder of the subjects tended to choose different responses from those typically observed. Thus, the use of explicit negatives with the standard

TABLE 5-1

Frequency of Selection Combinations for each Problem in Experiment 3

Selection	Type of Problem: Standard Abstract	Type of Problem: Standard Abstract with Explicit Negatives
P	7	2
NOT P	0	2
Q	0	0
NOT Q	0	0
P, Q	10	8
P, NOT Q[a]	2	2
All of the Cards	0	1
Other[b]	1	5

[a]This is the correct selection.

[b]The frequency of each of these selections was ≤ 2.

abstract problem does not lead to facilitation; but it appears to promote a more varied pattern of incorrect selections.

Analyses of Logic and Matching Indices

Two one-way ANOVAs were performed, one for the logic indices and one for the matching indices. Type of problem was the factor examined. The mean logic and matching indices for each problem are shown in Table 5-2.

Type of problem was not significant in the ANOVA for the logic indices. This finding agrees with the percentage correct results.

Type of problem, however, was significant in the ANOVA for the matching indices [$F(1,39) = 4.91$, $p < .05$]. There was significantly more matching for the standard abstract problem. This is consistent with the earlier finding of a more varied error pattern for the standard abstract problem with explicit negatives.

TABLE 5-2

Mean Logic and Matching Indices for each Problem in Experiment 3

	Type of Problem	
Index	Standard Abstract	Standard Abstract with Explicit Negatives
Logic	0.550	0.150
Matching	1.350	0.550

CHAPTER 6
EXPERIMENT 4

The results of Experiment 2 and the replication of Experiment 2 indicate that the facilitation for abstract schema problems disappears when the explicit negatives are removed from the NOT P and NOT Q cards. However, the results from Experiment 3 indicate that the use of explicit negatives in the standard abstract problem cannot produce facilitation. Thus, there appears to be some sort of interactive effect between the explicit negatives and the schema problem statements. Experiment 4 attempted to clarify this interaction.

In addition to pragmatic reasoning schemas and explicit negatives, Cheng and Holyoak's schema problems also employed a "checking" context. That is, subjects were told to imagine that they were an authority checking whether people were obeying certain regulations. Van Duyne (1974) first discussed what he called a "detective set" similar to the checking situation described above. He argued that this set might lead to facilitation on the problem because subjects would be more inclined to detect violators of the rule.

Pollard and Evans (1987) manipulated both problem content and detective set (what they called context) in a series of experiments. They found that neither factor alone promotes facilitation, but that there was a facilitative

effect when both were employed. Hence, the "checking" context may be responsible for some of the observed facilitation in the present Experiment 1 and in Cheng and Holyoak's work. It may interact with the explicit negatives on the NOT P and NOT Q cards.

To examine this possibility, the checking context was removed from the abstract permission schema problem and the use of explicit negatives was varied. If the checking context is necessary for the facilitative effect on abstract permission schema problems, then no facilitation should be observed, even for the problem with explicit negatives.

Method

Subjects

Forty University of Florida undergraduates enrolled in General Psychology courses served as subjects. Subjects participated as part of the research requirement for the course. None of the subjects had any previous experience with the selection task.

Design

The use of explicit negatives on the NOT P and NOT Q cards was the only factor manipulated. Subjects received only one problem. There were two conditions, with twenty subjects in each condition. An abstract permission schema problem with explicit negatives was used in one condition. An abstract permission schema problem without explicit

negatives was used in the other condition. Card order was varied in the same way as in the first three experiments.

Materials

The abstract permission problem with explicit negatives was as follows:

> The cards below contain information on four people: One side of each card indicates whether or not a person has taken action "A," the other indicates whether or not the same individual has fulfilled precondition "P."
>
> Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain regulation is being followed. The regulation is "If one is to take action 'A,' then one must first satisfy precondition 'P.'" Turn over only those cards that you need to check to be sure.

The problem was followed by drawings of four cards showing: "Has taken action A," "Has not taken action A," "Has fulfilled precondition P," and "Has not fulfilled precondition P."

The abstract permission problem without explicit negatives on the NOT P and NOT Q cards was as follows:

> The cards below contain information on four people: One side of each card indicates what action a person has taken,the other indicates what precondition a person has fulfilled.

> Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain regulation is being followed. The regulation is "If one is to take action 'A,' then one must first satisfy precondition 'P.'" Turn over only those cards that you need to check to be sure.

The cards were: "Has taken action A," "Has taken action B," "Has fulfilled precondition P," and "Has fulfilled precondition Q."

Procedure

The procedure was the same as in Experiment 3.

Results and Discussion

The results will be presented as in the first three experiments.

Percentage Correct Results

The percentage of subjects solving each of the problems was very low. Fifteen percent of the subjects solved the problem with explicit negatives, while none of the subjects solved the problem without explicit negatives. This difference was not significant. Thus, it appears that when the checking situation is removed from the permission schema problem, even the use of explicit negatives cannot bring about facilitation.

Selection Combinations Results

The frequency of the various card selection combinations are presented in Table 6-1. The most common answers were once again P only and P and Q; although, as in Experiment 3, the problem with explicit negatives led to a more varied error pattern.

Analyses of Logic and Matching Indices

Two one-way ANOVAs, one for the logic indices and one for the matching indices, were performed. The mean logic and matching indices for each problem are presented in Table 6-2. Type of problem was not significant in either ANOVA. Thus, both checking context and explicit negatives seem necessary in order to facilitate performance on the abstract schema problem. This will be further discussed in the last chapter.

TABLE 6-1

Frequency of Selection Combinations for each Problem in Experiment 4

Selection	Type of Problem: Abstract Permission With Explicit Negatives	Type of Problem: Abstract Permission Without Explicit Negatives
P	3	6
NOT P	2	0
Q	2	4
NOT Q	1	0
P, Q	5	4
P, NOT Q[a]	3	0
NOT P, Q	3	0
Q, NOT Q	0	3
Other[b]	1	3

[a]This is the correct selection.

[b]The frequency of each of these selections was ≤ 2.

TABLE 6-2

Mean Logic and Matching Indices for each Problem in Experiment 4

	Type of Problem	
Index	Abstract Permission With Explicit Negatives	Abstract Permission Without Explicit Negatives
Logic	0.00	0.05
Matching	0.60	0.95

CHAPTER 7
GENERAL DISCUSSION

The results from Experiment 1 supported Cheng and Holyoak's pragmatic reasoning schema theory of performance on the selection task. Subjects performed significantly better on the abstract permission and obligation schema problems than on the standard abstract selection task. No transfer between the schema problems and the standard abstract problem was observed, and the type of instructions (violation versus true-false) made no significant difference in subjects' performance on any of the problems.

In Experiment 2, the facilitation for schema problems was eliminated by removing the explicit negatives from the NOT P and NOT Q cards. Thus, by making one simple methodological change, the facilitation for the schema problems disappeared. It is important to remember that the original version of the selection task and all of those thematic versions discussed in the introduction did not employ explicit negatives. So it would appear that the facilitation on the schema problems is due to the use of these explicit negatives. However, if this were the case, then performance on the standard abstract problem with explicit negatives should have been at least slightly facilitated; yet it was not. However, this lack of effect

may have been due to their inclusion as parenthetical expressions rather than as the singular expressions on the cards. Overall, the results from Experiment 2 indicated that there might be some sort of interactive effect between the schema problem statements and the explicit negatives that led to facilitation.

The results from the replication of Experiment 2 clarified any ambiguity there may have been with the schema problem statements. The results of this replication were essentially the same as those of the original Experiment 2. Thus, the same conclusions can be drawn. There was no facilitative effect for the schema problems. It therefore can be concluded that the previously observed facilitation is due to something other than the cuing of pragmatic reasoning schemas.

Results from Experiment 3 indicated that explicit negatives alone do not provide facilitation on the standard abstract problem. The results on the standard abstract problem in the first two experiments indicated this. However, it was necessary to test the use of explicit negatives in the standard abstract problem when they were actually the main information on the NOT P and NOT Q cards and not simply parenthetical statements. These results provided further evidence that the facilitation for the schema problems was not due only to the use of explicit negatives.

The results from Experiment 4 showed that the inclusion of a checking context in the problem statement is also necessary for facilitation to occur. That is, one needs to include some sort of checking scenario or context that cues subjects to look for violators of the rule. However, this checking context alone is not enough to provide facilitation; or performance on the schema problems in Experiment 2 and the replication of Experiment 2 would have been facilitated. Thus, both explicit negatives and a checking context appear to be necessary for facilitation on the abstract schema problems.

Although the present findings cannot be accounted for by Cheng and Holyoak's pragmatic reasoning schema theory, a more recent schema-type theory can explain them: Cosmides's social contract theory (in press). Cosmides's social contract theory is based on social exchange, or situations in which one is obliged to pay a cost or meet a requirement in order to be entitled to receive a benefit. This type of social exchange develops in order for people to detect cheaters. If either the information surrounding a rule or the subjects' past experiences cause the subject to represent the terms of the rule as costs and benefits, then subjects will look for "cheaters," people who have not paid the cost but who have taken the benefit. Expressed as a selection task rule this would be "If you take the benefit then you pay the cost." Cosmides (in press) found that performance on all such rules was facilitated.

Interestingly, the schema problems used by Cheng and Holyoak (1985) and in the present Experiment 1 are also written in terms of costs and benefits. However, Cosmides claims that the cost-benefit structure in these problems is implicit and not explicit. For example, saying that one must fulfill or satisfy a precondition in order to be permitted to do something is just another way of saying that one must pay a cost or meet a requirement. In order to avoid a social contract interpretation of this rule, it would have to be written so that subjects would assume that one is no better off by taking action A than by not taking it, and no worse off by satisfying precondition P than by not satisfying it. Therefore, Cosmides claims that the facilitation observed on these schema problems is due to the use of social contracts and not pragmatic reasoning schemas.

Results from Experiment 2 indicated that by removing the explicit NOTs from the NOT P and NOT Q cards, there was no facilitation. If the schema problems are truly social contract problems, then why did removing the explicit NOTs affect performance on these problems?

Cosmides (personal communication, March 28, 1988) explains that the permission problem with explicit NOTs is probably interpreted as meaning that a person would rather take action A than not take it, or taking action A is a benefit relative to not taking it. For the permission problem without explicit NOTs, the NOT P card is "Has taken action B," instead of "Has NOT taken action A." This might

not be interpreted as a social exchange. Subjects may realize that one is still better off taking action A, than not taking it; but it does not address the value of action A compared to action B. It may be just as good or better to take action B as to take action A. Subjects therefore do not know that taking action A is a benefit relative to taking action B, and the whole cost-benefit structure of the original problem is lost. This argument also follows for the Q and NOT Q cards. This in turn makes the schema problems without explicit negatives non-social contract problems; and according to Cosmides' theory, there would be no facilitation on these problems.

This also explains performance in Experiment 3. Adding explicit negatives to the NOT P and NOT Q cards would not make the standard abstract problem a social contract problem, and therefore there would be no facilitation because it was not interpreted as a cost-benefit situation.

Results from Experiment 4 might also be explained in terms of Cosmides's theory. In this case it might be claimed that removing the checking context made the cost-benefit structure of the schema problems too implicit, even in those cases where explicit negatives were used. Hence, subjects were not able to determine that the problem was a cost-benefit situation.

Cosmides (personal communication, March 28, 1988) also claims that performance on the obligation schema problems can be explained using her theory. She argues that the cost-

benefit structure of the obligation problems is weaker, and therefore performance on this problem should not be as good as on the permission schema problem. Interpreted as a cost-benefit problem the obligation schema problem would be, "If the benefit comes about, then there is a cost which must be paid."

While Cosmides's explanation of the present results and those of Cheng and Holyoak (1985) is plausible, these findings can also be explained in terms of Evans's (1984) heuristic and analytic processing theory of reasoning. This theory does not assume that schemas, social contracts, or any other schema-type structures are cued.

Evans (1984) proposed a two-stage theory of reasoning. The first stage, heuristic processing, selects items of task information as relevant; and the second stage, analytic processing, operates on the selected items to generate inferences or judgments. On the selection task, Evans proposes that card selections do not reflect analytic processing and are due entirely to heuristic processing. Due to linguistic cues, subjects merely select the cards which match the values in the rule. The values mentioned, regardless of negatives, provide the linguistic topic of the sentence, and are thus more likely to be coded as relevant.

Facilitation by thematic context can also be attributed to relevance judgments, though semantically cued rather than linguistically cued. A person knows from experience that the drinking laws are relevant if you are drinking alcohol or

under the legal age for drinking alcohol. Thus, like matching bias for the abstract task, memory cuing can be explained by a heuristic process.

The present finding of facilitation when explicit negatives on the NOT P and NOT Q cards and the checking context were both employed can be explained in terms of the heuristic stage of processing. Evans (1983) has already found similar facilitative effects for a conditional truth-table evaluation task. The explicit negatives reduce the tendency to match and thus highlight the NOT P and NOT Q cases. Similarly, the checking context would highlight these cases because it creates a detective set to look for violators of the rule.

In summary, both theories provide plausible accounts of the present results and the findings of previous selection task studies; but the present experiments do not provide a crucial test between them. This remains a topic for future research. However, the present results clearly eliminate the pragmatic reasoning schema theory as a viable explanation of our present state of knowledge about performance on the selection task. Although a schema-type theory may ultimately provide the best explanation of performance on the selection task, it will not be the pragmatic reasoning schema theory.

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BIOGRAPHICAL SKETCH

Sherri L. Jackson was born on July 7, 1962, in Fort Rucker, Alabama. Ms. Jackson spent her formative years and completed all of her schooling in Massachusetts. After high school, Ms. Jackson attended Houghton College in Houghton, New York, for two years. She finished her undergraduate degree in 1984 at North Adams State College in North Adams, Massachusetts. She received her Master of Science degree from the University of Florida in August 1986, and anticipates completing her Ph.D. in August 1988. Ms. Jackson has accepted a position as assistant professor of Psychology at Jacksonville University beginning in September 1988.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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